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COMPARISONS OF DOLPHIN MORTALITY RATES BETWEEN DAY AND NIGHT SETS FOR THE U.S. EASTERN TROPICAL PACIFIC TUNA PURSE SEINE FISHERY

by

Atilio L. Coan, Jr., Kenneth E. Wallace, and Alan R. Jackson

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FOR THE U.S. EASTERN TROPICAL PACIFIC TUNA PURSE SEINE FISHERY

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INTRODUCTION

Yellowfin tuna (Thunnus albacares) and skipjack tuna (Katsuwonus pelamis) have been harvested by many countries in the eastern tropical Pacific (Figure 1) since the late 1910's (Joseph 1969). In its early stages, the fishery used mainly baitboat fishing techniques. During the period 1959-1961, many of the baitboats were converted to purse seiners (McNeely 1961) and since that period many new purse seiners have been added to the fleet. Purse seiners now account for over 98% of the surface gear fishing capacity in the eastern tropical Pacific. The annual yellowfin tuna catch has grown from approximately 45,000 mt in 1945 to over 240,000 mt in 1987.

Purse seiners in the eastern tropical Pacific have concentrated their fishing effort on three types of yellowfin tuna schools. Nets have been set on free-swimming, unassociated schools, schools associated with floating objects such as logs (both types are non-dolphin sets) or schools associated with dolphins, mainly Stenella attenuata and S. longirostris (dolphin sets). Dolphin sets have produced excellent catches of yellowfin tuna and the fish have been larger than those in non-dolphin sets. Fishing on dolphins has become the dominant mode of fishing, due in part to increases in the price paid for and abundance of large yellowfin tuna (IATTC 1987).

In the process of capturing yellowfin tuna with purse seines, dolphins often become entangled in the nets and drown (Perrin 1969, Green et al. 1971). Due in part to increased public concern over the incidental dolphin mortalities in dolphin sets, the National Marine Fisheries Service (NMFS) began monitoring dolphin mortality for the U.S. fishery by placing scientific technicians (observers) on U.S. purse seiners fishing in the eastern tropical Pacific in 1971 and the Marine Mammal Protection Act was enacted in 1972. In 1979, the Inter-American Tropical Tuna Commission (IATTC) started its own international tuna-dolphin program, that placed observers on both U.S. and foreign fishing vessels.

The fishing industry and NMFS have developed modifications to purse seines (Medina Panel, 1½" mesh net) and purse seining operations (backdown, a method used to release live dolphins from the net) to reduce dolphin mortality (Barham et al. 1977, Coe and Sousa 1972). In the early 1980's, industry experimented with high intensity 140,000-lumen floodlights (referred to as high intensity floodlights in this report) on vessels to reduce dolphin mortality in dolphin sets where any portion of the backdown procedure occurs in darkness. The lights, originally supplied by the IATTC and Porpoise Rescue Foundation (PRF),

became a mandatory gear requirement for all certificated U.S. vessels on July 1, 1986. In 1987 and 1988, PRF and the American Tunaboat Association continued to loan additional lights to skippers interested in experimenting with multiple lights.

The purpose of this report is to document and analyze differences in observed dolphin mortality and mortality rates between dolphin sets where any portion of the backdown procedure occurs in darkness (night sets) and dolphin sets made during the day (day sets). Changes in day set and night set dolphin mortalities and mortality rates resulting from inclusion of seriously injured animals in dolphin mortality data will be assessed. The effects of placing a curfew on night sets and using the 140,000-lumen floodlights to reduce mortalities in night sets will also be discussed.

DATA AND METHODS

Data were obtained from both IATTC and NMFS observed trips of U.S. purse seiners for the period January 1, 1979, to July 1, 1988. Files were developed by calendar year and contained, for each cruise and set, number of dolphins killed, tons of yellowfin tuna caught, number of seriously injured animals, position, date, designation whether the set was a day or night set and, if a night set, whether floodlights were used. Mortality rates were calculated as the total number of animals killed divided by the total number of dolphin sets (kill/set) or by total tonnage of yellowfin tuna caught (kill/ton) in dolphin sets. Because of the differences in the way data were collected by IATTC and NMFS, different criteria were developed to separate day and night sets.

NMFS Data

Separation of day and night sets was accomplished by looking at two NMFS database elements: SUNDOWN and LIGHTS DURING BACKDOWN. The element SUNDOWN indicates whether or not the backdown maneuver occurred in darkness. LIGHTS DURING BACKDOWN indicates whether or not lights were used to illuminate the backdown channel. A set was considered a night set if the observer indicated that backdown occurred in darkness and a light was used to illuminate the backdown channel. If the observer indicated that backdown occurred in darkness but no light was used, the original data (including non-coded handwritten notes) were screened to determine whether there was any indication that there was enough twilight for the set to be considered a day set. Otherwise, the set was considered a night set (Salomons pers. comm.¹). Some sets did not have backdown information recorded. In these cases, the time of the end of the set was compared to the time of sunset and those that were obviously day sets were assigned as day sets and the others were eliminated from further analysis.

¹Robert Salomons, LMR Fisheries Research, Inc., 11855 Sorrento Valley Rd., Suite A, San Diego, CA 92121-1028.

Additionally, night sets were divided into sets where high intensity floodlights were used and sets where other types of lights were used instead. This was accomplished by looking at the observer's notes for each set (Salomons pers. comm.).

The total number of seriously injured animals in each set was obtained from the database element KNOWN INJURED. An animal was considered seriously injured if it was bleeding, had obviously broken bones or had been run through the power block. KNOWN INJURED includes injured animals that were released alive as well as those that were released from the net but their status, dead or alive, could not be determined.

If the time of sundown was not recorded, sundown times were calculated from the geographical position and date (Bowditch 1966). Calculated sundown times are accurate to ± 3 minutes for positions between 30°N and 30°S latitudes. Sundown times were also supplied by Salomons and were compared to the calculated sundown times. Discrepancies between sundown times and logged times of backdowns and other set times were eliminated by referring to the original observer's notes.

IATTC Data

Separation of day and night sets was accomplished by looking at two IATTC set log database elements: LIGHTS and SUNDOWN. The value of the element LIGHTS provides the answer to the question: "If all or part of backdown occurred in the dark, were lights used by the vessel to illuminate any part of the backdown channel?" The element SUNDOWN indicates the local time (ship's time) of sunset, if sunset occurred during the set.

A set was considered a night set if the value of LIGHTS was "yes" (night set with use of lights) or "no" (night set without use of lights). A set was considered a day set if the value of LIGHTS was "not applicable", unless there was no backdown and the set ended after sunset -- those sets were categorized as indeterminate (neither a day nor a night set) and were eliminated from further analysis.

Night sets were divided into sets where high intensity floodlights were used, sets where other types of lights were used instead and sets where no lights were used. This was accomplished by examining observer notes for each set (Salomons and Bratten, pers. comm.²).

The total number of seriously injured animals for each set was obtained from set log kill information. An animal was considered seriously injured if it was bleeding profusely or had broken bones or severely torn extremities. Unlike NMFS data collection methods, IATTC observers presume animals run through the powerblock to be dead.

²Dave Bratten, Inter-American Tropical Tuna Commission, c/o Scripps Institution of Oceanography, La Jolla, CA 92093.

The time of sundown is routinely recorded on the set log by IATTC observers. Therefore, no sundown time was calculated from geographic position and date.

ELIMINATION OF UNUSABLE DATA

In the process of compiling the NMFS and IATTC data, certain sets were eliminated: 1) all sets where marine mammals were accidentally caught (e.g., in non-dolphin sets) (Table 1); 2) sets where the tons of yellowfin caught or the marine mammal kill was missing, because kill/set and kill/ton information would have been invalid (Table 2); and 3) sets where there was no backdown and the time of the end of the set was after sunset, because there was no way to assign the set to the day or night set category (Table 3). The sets eliminated represented approximately 2% of the total number of sets, 1% of the total dolphin mortality and 1% of the total yellowfin catch considered.

COMPARISONS OF DAY AND NIGHT SETS

During the period January 1, 1979, to July 1, 1988, 19,797 dolphin sets, producing 281,079 short tons (st) of yellowfin tuna, were observed by observers aboard U.S. tuna seiners in the eastern tropical Pacific. Approximately 90% of these sets (17,736) and the associated yellowfin tuna catch (251,096 st) were made during the day (Figure 2A,B). Night sets were much less frequent, accounting for only 10% of both dolphin sets (1,849) and yellowfin tuna catch (29,406 st). Due to the limited number of night sets, no attempt was made to stratify the data by area or dolphin stocks in comparing day and night set mortalities.

Catch rates, in short tons of yellowfin tuna caught per observed dolphin set (st/set) increased from approximately 11 st/set in the early 1980's to approximately 25 st/set in 1986 and then dropped to approximately 16 st/set in 1987 and 1988 (Figure 3). In general, night sets had higher catch rates (0.5 to 3.9 st/set higher) than day sets except in two years, 1984 and 1987, where night set catch rates were slightly lower. Catch rates in 1986 showed the greatest difference when night catch rates were approximately 4 st/set higher than day sets.

Day sets contributed the highest percentage of the dolphin mortality in all but one year, 1984, where day and night sets contributed the same proportion (Figure 4). Total mortality in day sets was 51,382 animals and in night sets, 23,451. The higher mortality in day sets was probably due to the large number of these sets as compared to night sets. However, average yearly dolphin mortality rates for day sets, in terms of kill/set and kill/ton, were always lower than rates for night sets (Figure 5A,B). The greatest differences between day and night kill rates were observed in 1986 when night kill/set was 6.4 times day kill/set and in 1984 when night kill/ton was 7.6 times day kill/ton.

The annual percentages of sets at various levels of dolphin mortality (e.g., zero kill sets, 1-5, 6-10, 11-15, >15 animals per set) had very similar distributions between day and night sets (Figure 6A-E). Night sets consistently had higher percentages of sets at all levels of dolphin mortality except for zero kill sets. The greatest difference between the percentages occurred in zero kill sets, where day sets were as much as 20% higher than night sets. In general, day sets had higher percentages than night sets of sets with zero animals killed and lower percentages of sets with more than 15 animals killed.

Statistical Tests of Differences Between Day and Night Sets

A Wilcoxon paired-sample test (Zar 1974, Siegel 1956) was used to compare day and night set annual catch rates, mortality rates (kill/set and kill/ton), and percentages of sets with zero, 1 to 5, 6 to 10, 11 to 15 and greater than 15 animals killed. The null hypothesis, in each case, was that the catch rates, mortality rates or percentages of sets at various levels of mortality were the same in day and night sets. The null hypothesis was rejected, at the 5% level of significance, in all cases except for catch rates and percentage of sets with 1 to 5 and 11 to 15 animals killed. Therefore, annual mortality rates, in both kill/set and kill/ton, are statistically different for sets made during the day and during the night, and night sets had significantly different percentages than day sets of zero kill sets and sets with 6 to 10 and greater than 15 animals killed. Day and night sets had statistically similar catch rates and percentage of sets with 1 to 5 and 11 to 15 animals killed.

The Wilcoxon paired-sample test was also run to compare day and night mortality rates for individual cruises, where both day and night sets occurred. The null hypothesis was that mortality rates (kill/set) for day and night sets are the same. Only cruises that had 2 or more day sets and 2 or more night sets were included in the analysis (Table 4). The null hypothesis was rejected, at the 5% level of significance, in all but one year, 1988, and when all cruises during the period January 1, 1979, to July 1, 1988, were considered, the null hypothesis was still rejected.

INCLUSION OF SERIOUSLY INJURED ANIMALS

Inclusion of seriously injured animals in the annual observed dolphin mortalities increased mortalities by 44 to 435 animals for day sets and 14 to 130 animals for night sets (Table 5). The effect on annual kill/set and kill/ton of yellowfin tuna caught, for both night and day sets, was an increase of less than 1 animal/set (Table 5). Therefore, inclusion of seriously injured animals in the observed mortality data would not have had an appreciable effect on observed mortality rates. The effects, however, on total estimated mortality is unknown, and is being investigated (Oliver and Edwards, in press).

ELIMINATION OF EXTREMELY HIGH KILL SETS

Due to the relatively small number of sets that occur at night, sets with extremely high dolphin mortality (>100 animals) had more of an effect on changing annual mortality rates in night sets than in day sets. During the period January 1, 1979, to July 1, 1988, 55 day sets (0.3% of observed day sets) and 54 night sets (2.9% of the observed night sets) had dolphin mortalities greater than 100 animals. All of these sets were associated with problems such as canopies (a billow of net that prevents dolphins from surfacing), equipment failure or net collapses. Elimination of these sets with kills greater than 100 animals would decrease night time mortality rates, as kill/set, by as much as 68% (Figure 7A,B). Day set mortality rates would also decrease by 12% to 32%. Total mortality would have been reduced 52% for night sets and 20% for day sets (Figure 7C,D). Therefore, elimination of problem sets will significantly reduce dolphin kill rates and total mortality in both day and night sets. Reductions in mortality even beyond those shown here could be achieved, since only sets with more than 100 animals killed were eliminated in this analysis

COMPARISONS OF FLOODLIGHT USE AND NONUSE IN NIGHT SETS

In order to assess the value of high intensity floodlights in the reduction of night set dolphin mortality, night sets that used these lights were separated from night sets where any other types of light were used. In general, night sets in which high intensity floodlights were used produced lower mortality rates (by 19% to 70%) than night sets where other types of lights were used (Figure 8). The greatest difference occurred in 1988 when kill/set in sets using high intensity floodlights was approximately 70% less than kill/set in sets using other types of light. A Wilcoxon paired-sample test run on these data showed that kill/set in sets using high intensity floodlights and kill/set in sets using other types of light was significantly different at the 5% level of significance. These results indicate that floodlights did reduce night set mortality rates and therefore, their use should be continued. However, mortality rates (kill/set) in night sets using floodlights continue to be significantly greater than mortality rates from day sets.

EFFECTS OF CURFEWS ON NIGHT SETS

The effects of placing curfews (limitations on starting sets at various times before sundown; all sets beginning after sundown are also eliminated) on night sets were examined by eliminating sets, by 15-minute intervals, that began up to 90 minutes before sunset (Table 6). Curfews on sets beginning up to 60 minutes before sunset would have decreased kill/set at night by as much as 9%. Elimination of sets starting 75 to 90 minutes before sunset increased kill/set at night by approximately 50%. Total observed mortality in night sets would have decreased under any of the curfews; in some cases by as much as 85%.

Any curfew on night sets would have also eliminated some day sets that started within the curfew limit and finished before sundown. Curfews on night sets beginning up to 90 minutes before sundown would have decreased day set mortality rates by as much as 2% and total observed mortality by approximately 6%. However, a maximum of 4% of the day sets (636 sets) and 4% (8,700 st) of the yellowfin tuna catch would have been lost.

Therefore, curfews on night sets would have decreased the total observed mortality in both day and night sets. The amount of this decrease could have been as high as 85% for night sets. Finally, approximately 4% of the yellowfin tuna caught in valid day sets would have been lost along with 89% (26,285 st) of the yellowfin tuna caught by eliminating night sets.

CONCLUSIONS

Night sets contributed 30% of the annual observed mortality, and killed animals at a significantly higher rate than day sets. These results are the same as those obtained by the IATTC (IATTC 1984) and generally are attributed to:

- 1) Reduced visibility that may have hampered the operator from seeing dolphin release operations, configuration of the backdown channel (canopies and cork sinkage), hand signals from rescuers, and numbers of animals remaining submerged or at the surface in the net.

- 2) Reluctance to place rescuers in the water during darkness due to safety concerns. Rafts and speedboats are used to rescue dolphins in night sets, but swimmers are almost never used in night sets. In contrast, swimmers are frequently used in day sets to hand release dolphins during the backdown procedure.

- 3) Sets that would have been completed well before darkness, but because of gear malfunctions and other problems were completed after dark.

Inclusion of seriously injured animals as part of the annual mortality did not significantly change differences between day and night sets.

Use of high intensity floodlights, during the period 1982 to 1988, in night sets decreased kill/set over night sets that used other sources of light. However, even with the use of floodlights, night set mortality rates (kill/set) did not reach parity with day set mortality rates.

Curfew on night sets of up to 90 minutes before sundown reduced total mortalities in night sets as much as 85% and day sets 6%. However, losses in valid day sets and yellowfin catches occurred.

Our analysis showed that some cruises had no significant differences between their day and night mortality rates. If these

cruises are related to specific skippers or vessels, then allowing these skippers or vessels to continue night sets even under a curfew would lessen the total amount of tuna lost under the curfew without increasing night-time mortality rates.

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Table 1. Number of sets, marine mammal mortality and tons of yellowfin tuna eliminated from NMFS and IATTC observer data because sets were non-dolphin sets that accidentally killed marine mammals.

<u>YEAR</u>	<u># SETS</u>	<u>MORTALITY</u>	<u>YELLOWFIN</u>
1979	11	4	91
1980	16	4	72
1981	24	1	91
1982	38	5	269
1983	15	11	46
1984	1	0	0
1985	2	0	0
1986	2	0	0
1987	23	45	456
1988	2	0	4
TOTAL	134	70	1029

Table 2. Number of sets, marine mammal mortality and tons of yellowfin tuna eliminated from NMFS and IATTC observer data because of missing information on tons of yellowfin tuna caught or number of marine mammals killed.

<u>YEAR</u>	<u># SETS</u>	<u>MORTALITY</u>	<u>YELLOWFIN</u>
1979	3	30+	16+
1980	2	100+	50+
1981	0	0	0
1982	2	57+	2
1983	0	0	0
1984	0	0	0
1985	0	0	0
1986	2	16	0+
1987	0	0	0
1988	0	0	0
TOTAL	9	203+	68+

+ Means that an amount greater than the value shown should be used. However, that value could not be determined since the data were missing.

Table 3. Number of sets, marine mammal mortality and tons of yellowfin tuna eliminated from NMFS and IATTC observer data because there was no backdown information recorded and the set ended after sundown.

<u>YEAR</u>	<u># SETS</u>	<u>MORTALITY</u>	<u>YELLOWFIN</u>
1979	18	15	14
1980	22	16	35
1981	25	78	127
1982	22	8	2
1983	10	24	0
1984	7	1	2
1985	36	71	141
1986	17	31	44
1987	48	109	201
1988	7	27	11
TOTAL	212	380	577

TABLE 4. Results of a Wilcoxon paired-sample test to compare differences in dolphin mortality rates (kill/set) between day and night sets by cruise. Only cruises that had at least two day and night sets were included. Critical values are at the 5% level of significance.

<u>YEAR</u>	<u>NUMBER CRUISES</u>	<u>DIFFERENCES</u>		<u>CRITICAL VALUES</u>	<u>ACTION</u>
		<u>ZERO</u>	<u>MINUS</u>		
79	59	2	288	579	REJECT
80	41	0	200	279	REJECT
81	40	1	179	249	REJECT
82	44	0	253	327	REJECT
83	23	1	46	65	REJECT
84	19	0	20	46	REJECT
85	40	0	148	265	REJECT
86	35	0	81	195	REJECT
87	99	1	1683	1832	REJECT
88	21	0	88	58	ACCEPT
TOTAL	421	5	20514	49311	REJECT

NULL HYPOTHESIS: DAY AND NIGHT SET MORTALITY RATES (KILL/SET) ARE THE SAME.

ALTERNATE HYPOTHESIS: DAY AND NIGHT SET MORTALITY RATES ARE DIFFERENT.

Table 5. Annual increases in observed dolphin mortality, and mortality rates (kill/set, kill/ton) if seriously injured animals are included in mortality data.

<u>DAY SETS</u>						
<u>YEAR</u>	<u>INCREASE</u>			<u>PERCENT INCREASE</u>		
	<u>MORTALITY</u>	<u>KILL/SET</u>	<u>KILL/TON</u>	<u>MORTALITY</u>	<u>KILL/SET</u>	<u>KILL/TON</u>
1979	435	0.1637	0.016	8.22	8.23	8.18
1980	263	0.13	0.013	5.57	5.57	5.55
1981	321	0.1555	0.0144	5.61	5.61	5.59
1982	204	0.121	0.0115	3.05	3.05	3.05
1983	64	0.0707	0.0069	2.49	2.49	2.50
1984	56	0.0772	0.004	2.46	2.46	2.41
1985	99	0.0575	0.0032	1.71	1.71	1.67
1986	53	0.044	0.0019	1.10	1.10	1.12
1987	207	0.0542	0.0031	2.11	2.11	2.11
1988	44	0.0474	0.0028	1.19	1.19	1.16

<u>NIGHT SETS</u>						
<u>YEAR</u>	<u>INCREASE</u>			<u>PERCENT INCREASE</u>		
	<u>MORTALITY</u>	<u>KILL/SET</u>	<u>KILL/TON</u>	<u>MORTALITY</u>	<u>KILL/SET</u>	<u>KILL/TON</u>
1979	76	0.3064	0.0248	3.13	3.12	3.13
1980	130	0.8176	0.074	6.80	6.80	6.81
1981	72	0.4186	0.0365	3.59	3.59	3.59
1982	50	0.2427	0.0181	1.86	1.86	1.85
1983	23	0.3108	0.0287	5.76	5.76	5.76
1984	30	0.2941	0.0161	1.29	1.29	1.28
1985	22	0.1084	0.0059	0.78	0.78	0.79
1986	34	0.2112	0.0077	0.82	0.82	0.82
1987	97	0.2214	0.0128	2.81	2.81	2.81
1988	14	0.1628	0.0096	1.11	1.11	1.11

Table 6. Decreases in total (January 1, 1979 to July 1, 1988) observed sets, dolphin mortality, tons of yellowfin tuna caught and mortality rates (kill/set, kill/ton) under a curfew that eliminates sets beginning up to 90 minutes before sundown and all sets beginning after sundown. Minus percent decreases are increases.

<u>DAY SETS</u>										
<u>CURFEW</u>	<u>SETS</u>	<u>MORTALITY</u>	<u>TONS</u>	<u>KILL/SET</u>	<u>KILL/TON</u>	<u>PERCENT DECREASE</u>				
						<u>SETS</u>	<u>MORTALITY</u>	<u>TONS</u>	<u>KILL/SET</u>	<u>KILL/TON</u>
none	17736	51382	251096	2.8970	0.2046	0.00	0.00	0.00	0.00	0.00
15	17667	50912	250188	2.8818	0.2035	0.39	0.91	0.36	0.53	0.56
30	17654	50797	250069	2.8774	0.2031	0.46	1.14	0.41	0.68	0.73
45	17630	50703	249884	2.8760	0.2029	0.60	1.32	0.48	0.73	0.84
60	17548	50518	248907	2.8788	0.2030	1.06	1.68	0.87	0.63	0.82
75	17363	49661	246059	2.8602	0.2018	2.10	3.35	2.01	1.27	1.37
90	17101	48431	242356	2.8321	0.1998	3.58	5.74	3.48	2.24	2.34

<u>NIGHT SETS</u>										
<u>CURFEW</u>	<u>SETS</u>	<u>MORTALITY</u>	<u>TONS</u>	<u>KILL/SET</u>	<u>KILL/TON</u>	<u>PERCENT DECREASE</u>				
						<u>SETS</u>	<u>MORTALITY</u>	<u>TONS</u>	<u>KILL/SET</u>	<u>KILL/TON</u>
none	1849	23451	29406	12.6831	0.7975	0.00	0.00	0.00	0.00	0.00
15	1448	17744	23625	12.2541	0.7511	21.69	24.34	19.66	3.38	5.82
30	1169	14696	19081	12.5714	0.7702	36.78	37.33	35.11	0.88	3.42
45	843	9711	14488	11.5196	0.6703	54.41	58.59	50.73	9.17	15.95
60	526	6379	9585	12.1274	0.6655	71.55	72.80	67.40	4.38	16.55
75	293	4477	5098	15.2799	0.8782	84.15	80.91	82.66	-20.47	-10.12
90	188	3581	3121	19.0479	1.1474	89.83	84.73	89.39	-50.18	-43.87

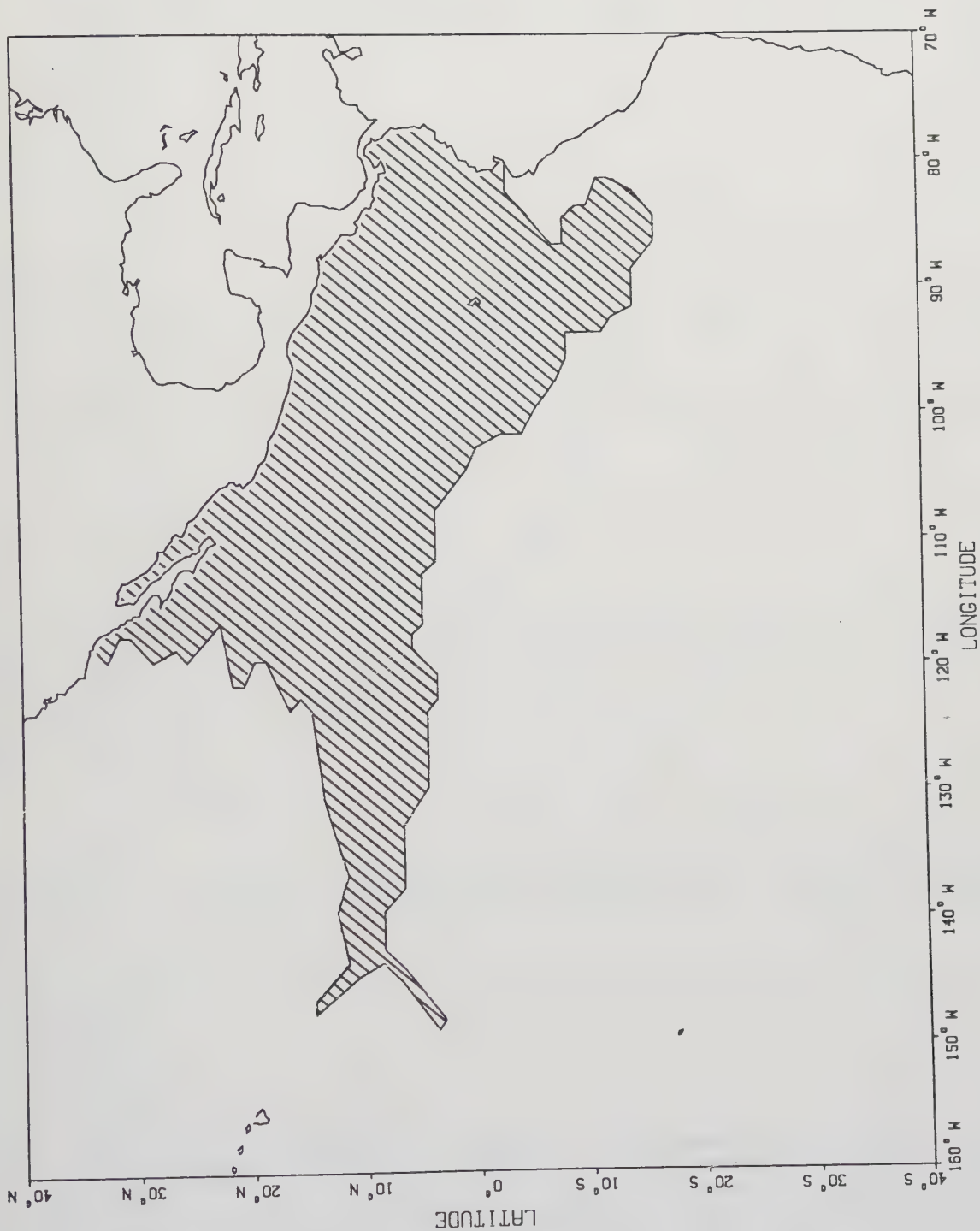


Figure 1. Area historically fished for yellowfin tuna by U.S. fishermen. Scientific observers are placed on purse seiners fishing in this area.

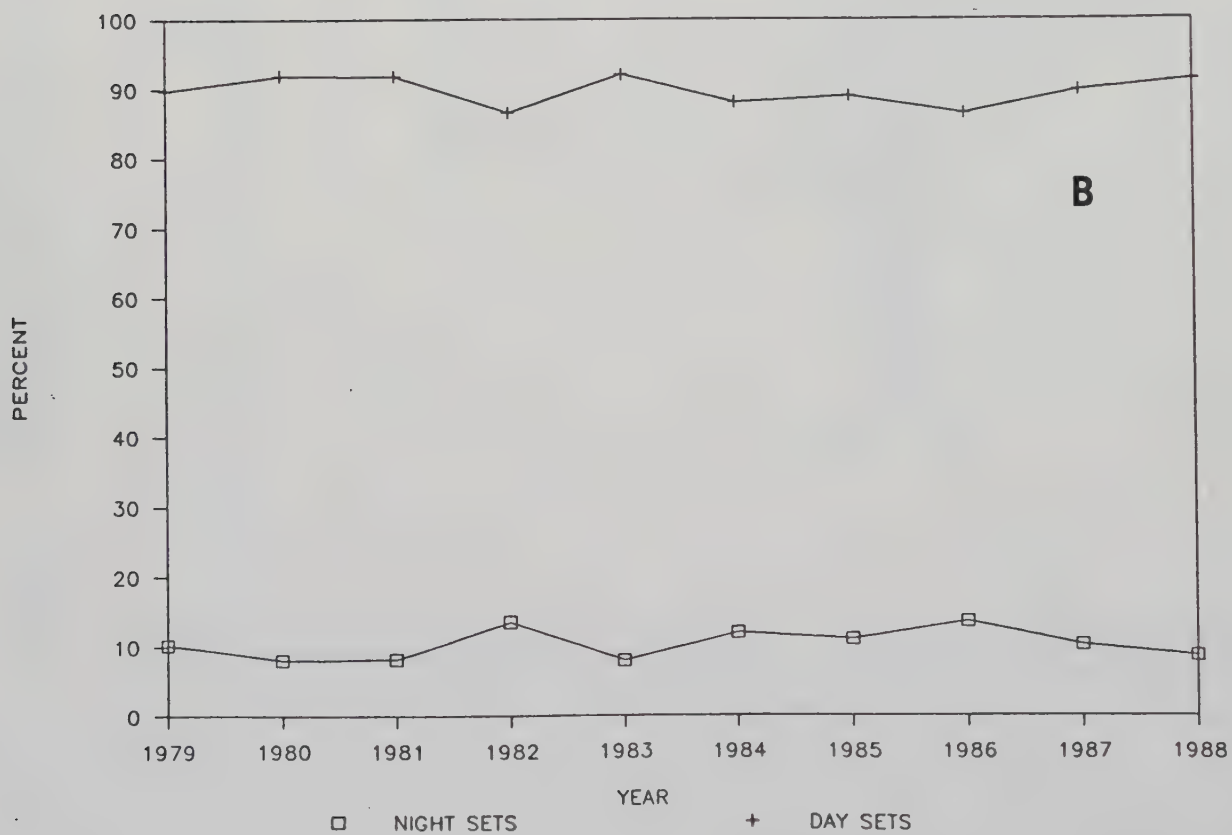


Figure 2. Annual percentages of observed dolphin sets (A) and yellowfin tuna catch (B) made in day and night sets.

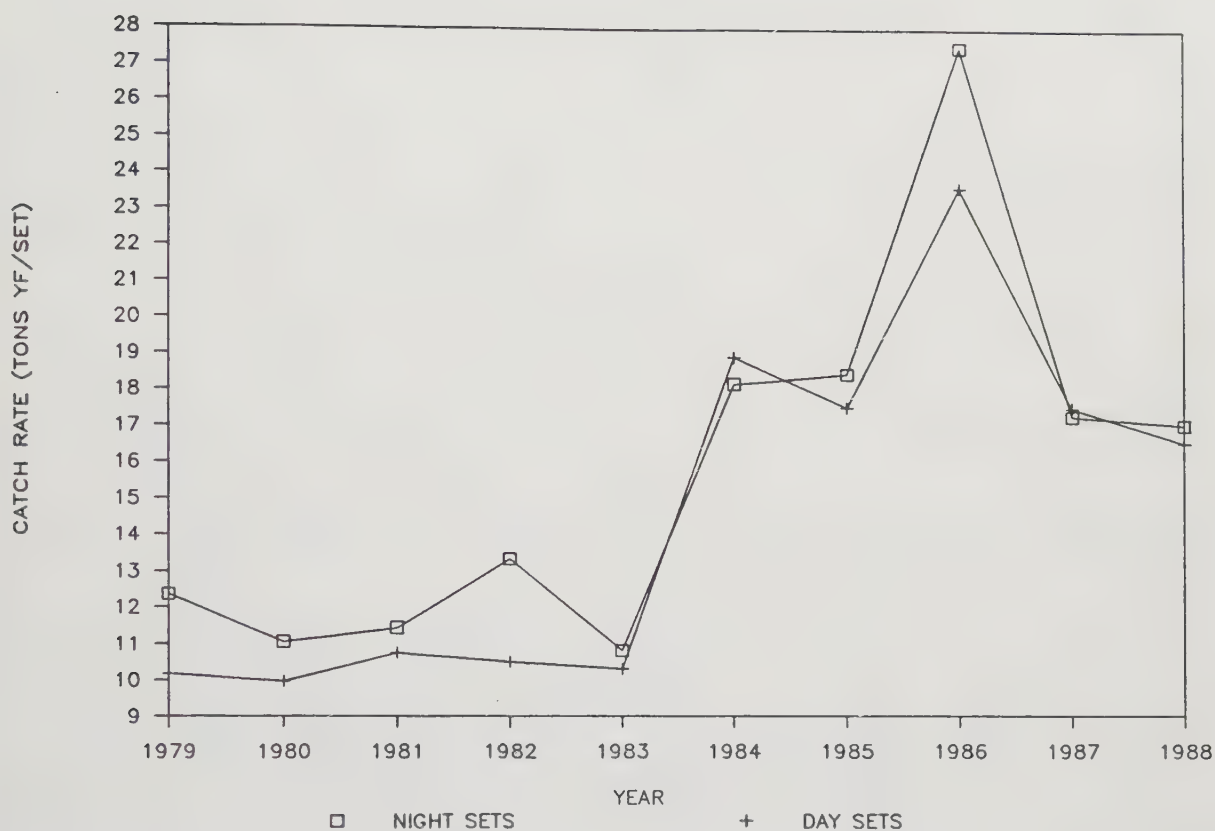


Figure 3. Annual catch rates in short tons of yellowfin tuna caught per observed dolphin set for day and night sets.

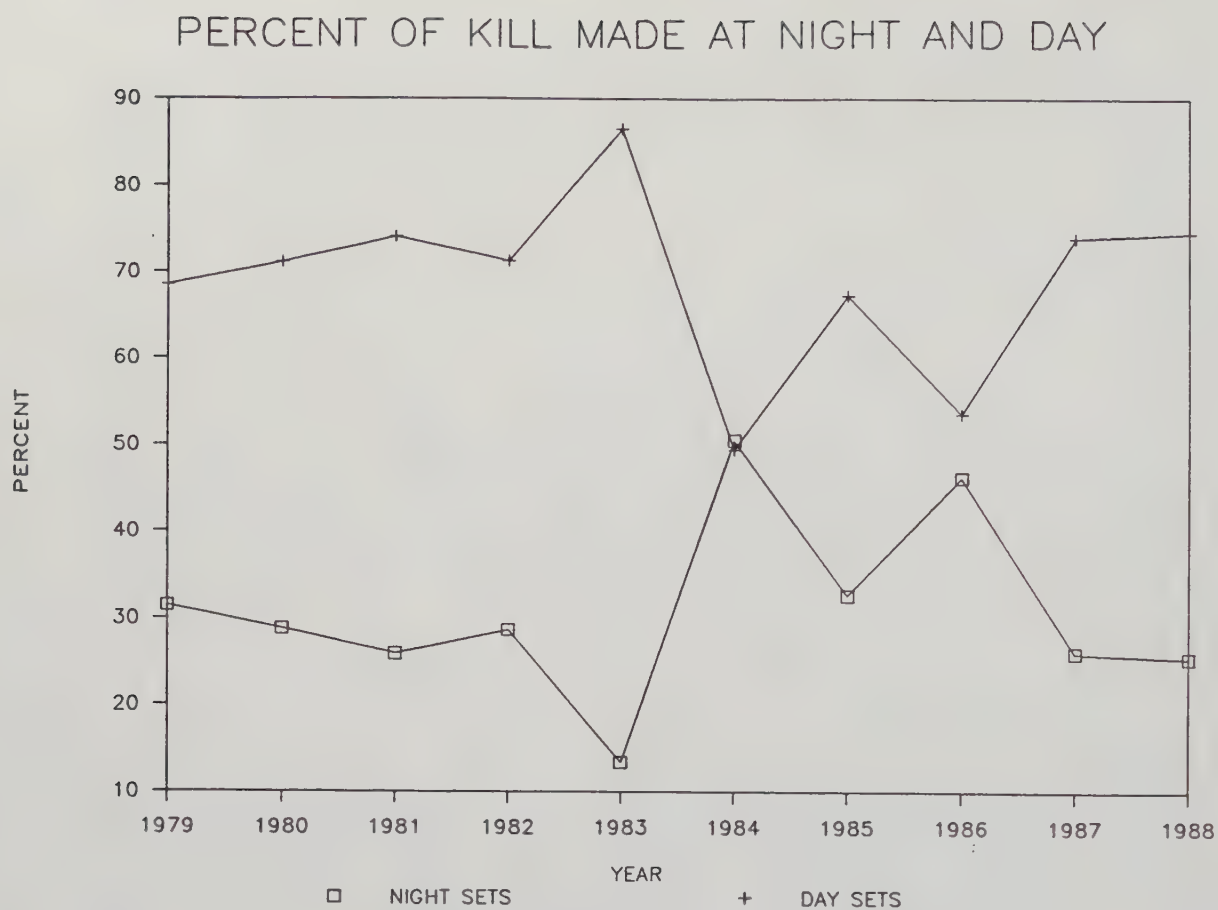


Figure 4. Annual percentages of observed dolphin mortality in day and night sets.

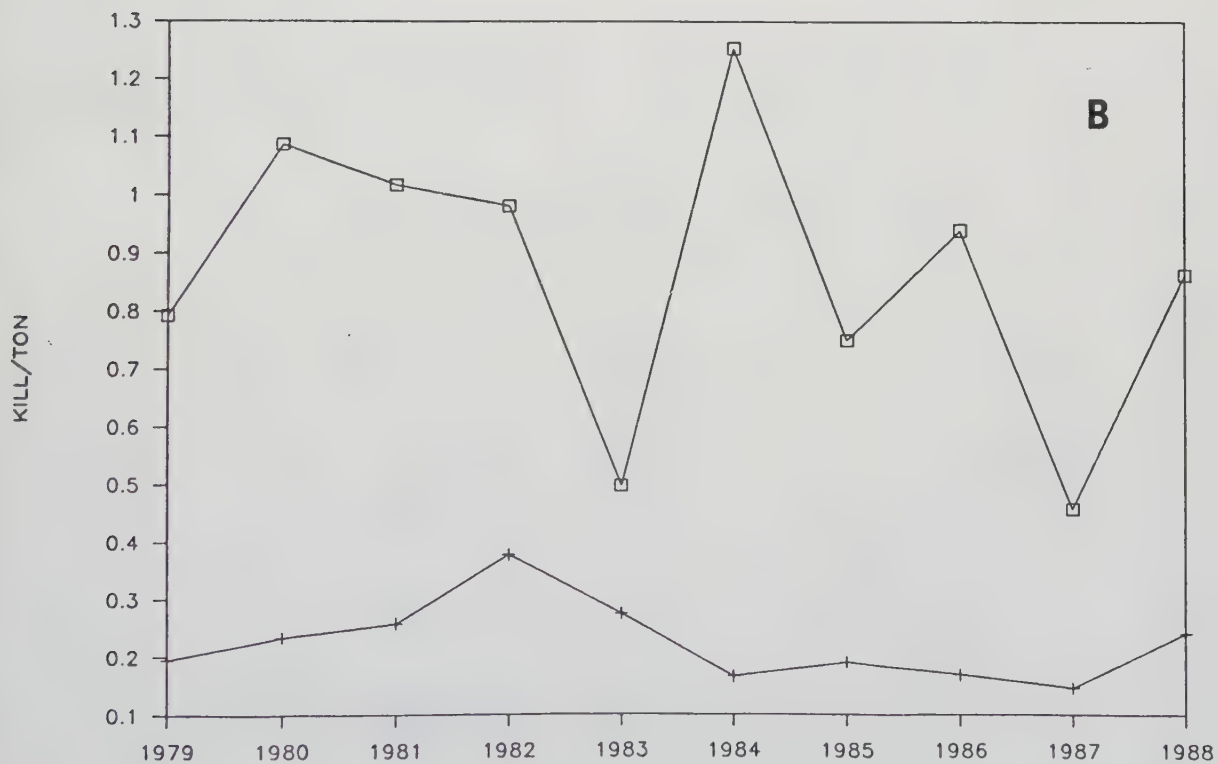
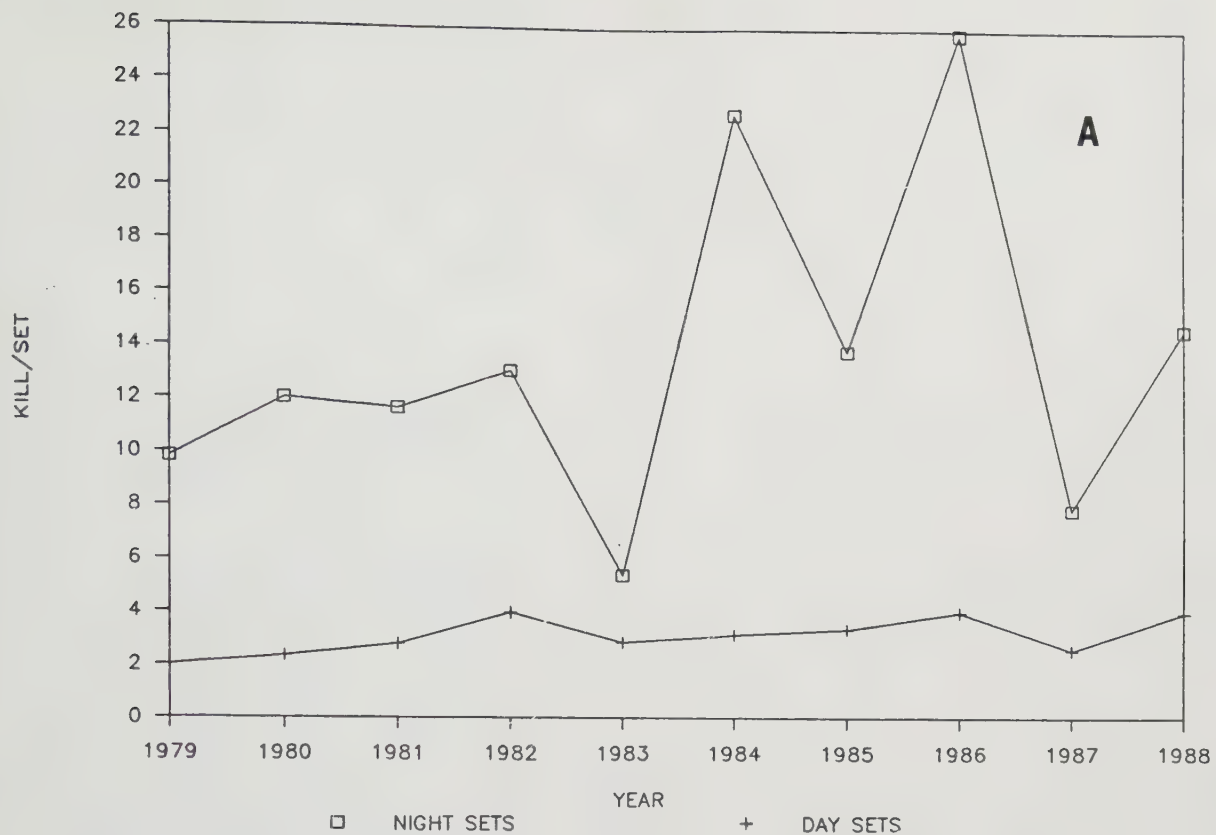
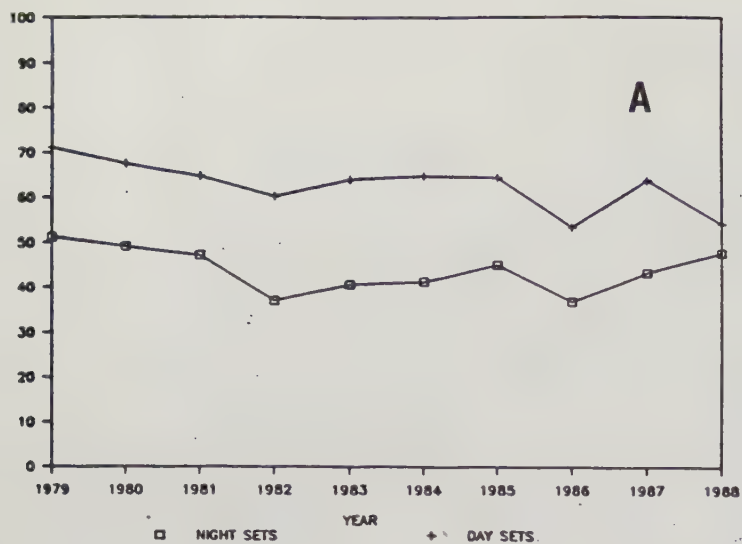
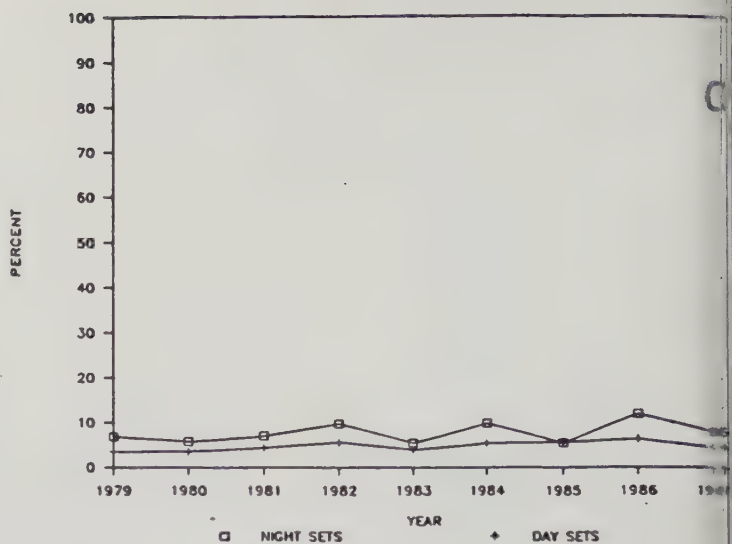


Figure 5. Annual observed dolphin mortality rates in kill/set (A) and kill/ton of yellowfin tuna caught (B) for day and night sets.

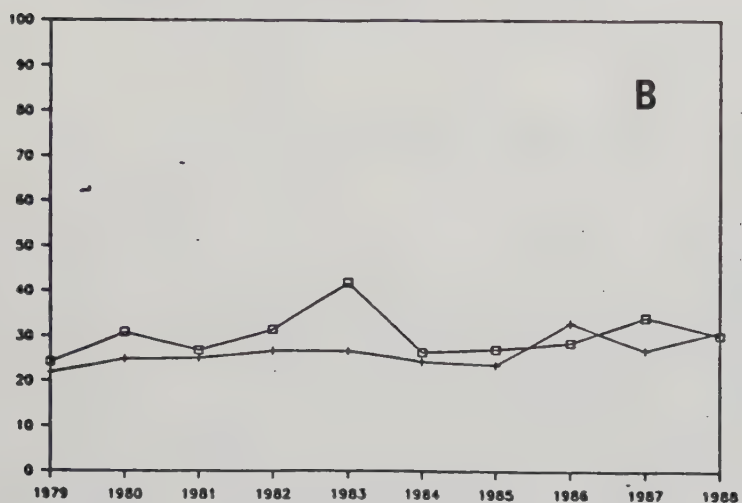
PERCENT OF SETS WITH ZERO KILL



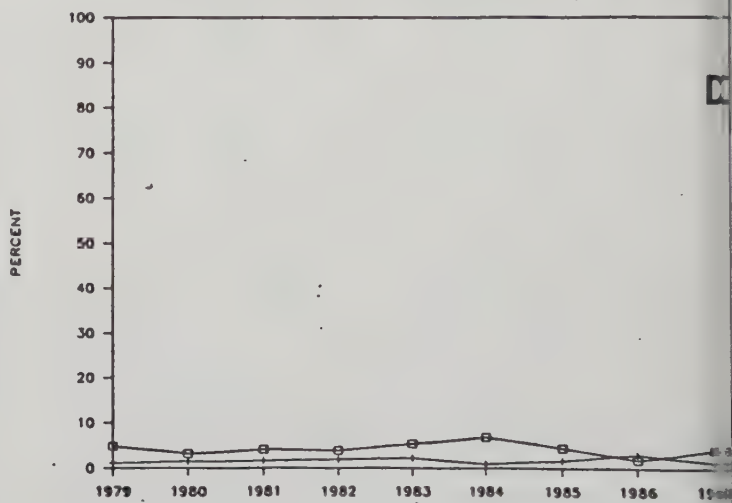
PERCENT OF SETS WITH 6 TO 10 KILL



PERCENT OF SETS WITH 1 TO 5 KILL



PERCENT OF SETS WITH 11 TO 15 KILL



PERCENT OF SETS WITH > 15 KILL

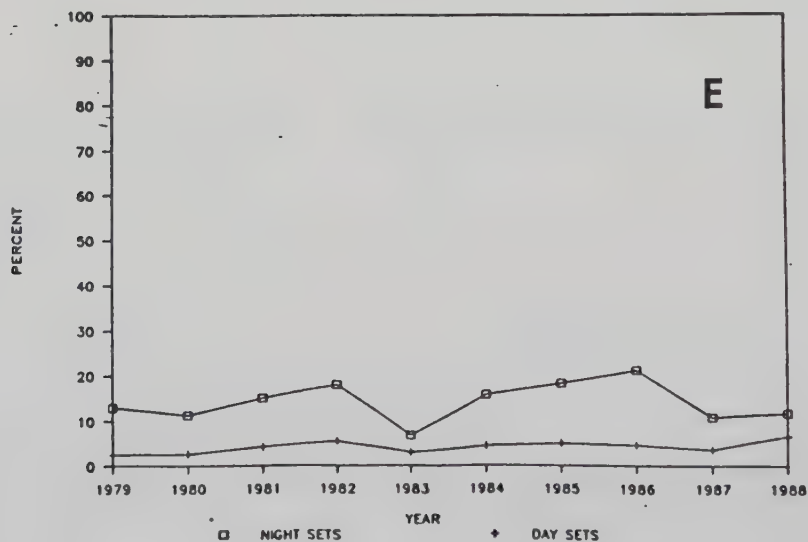
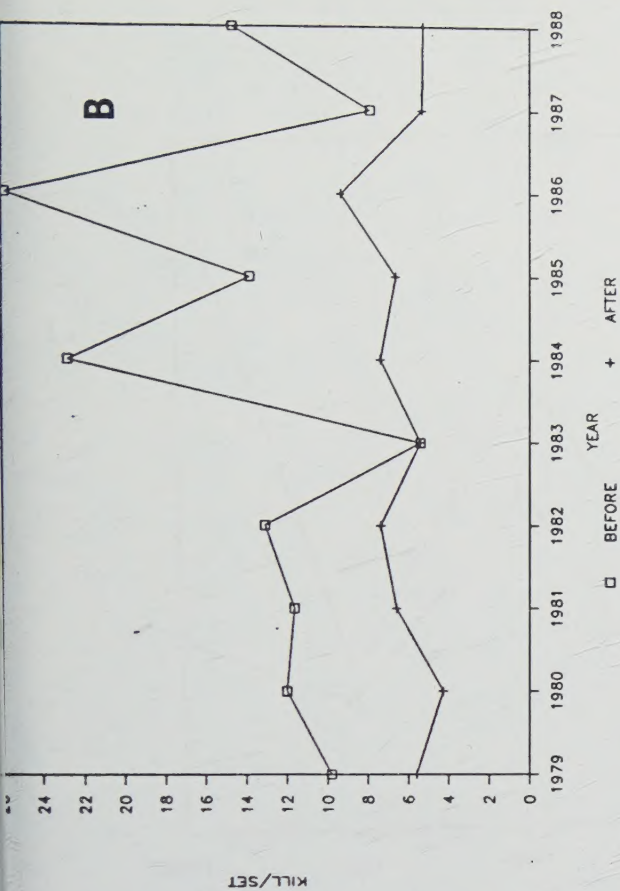
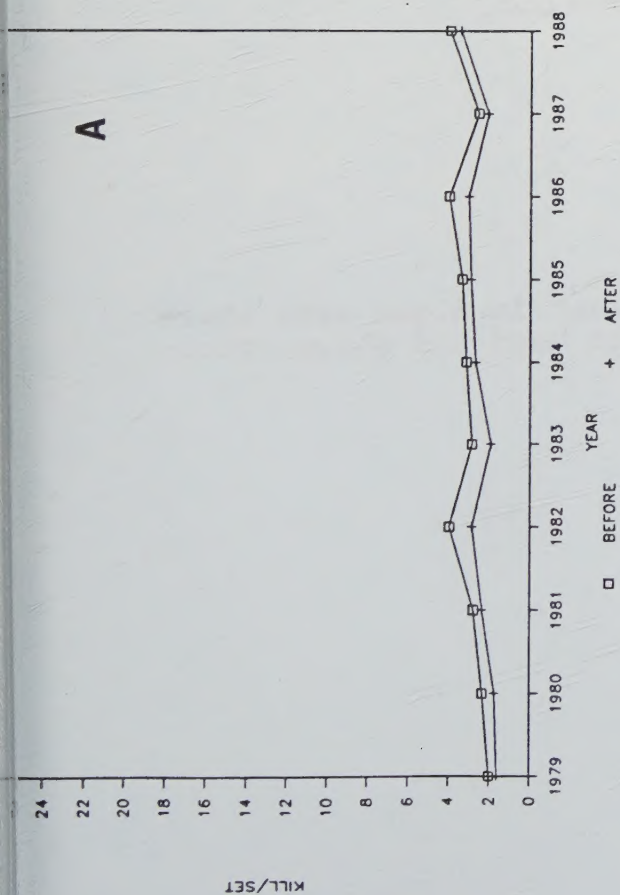
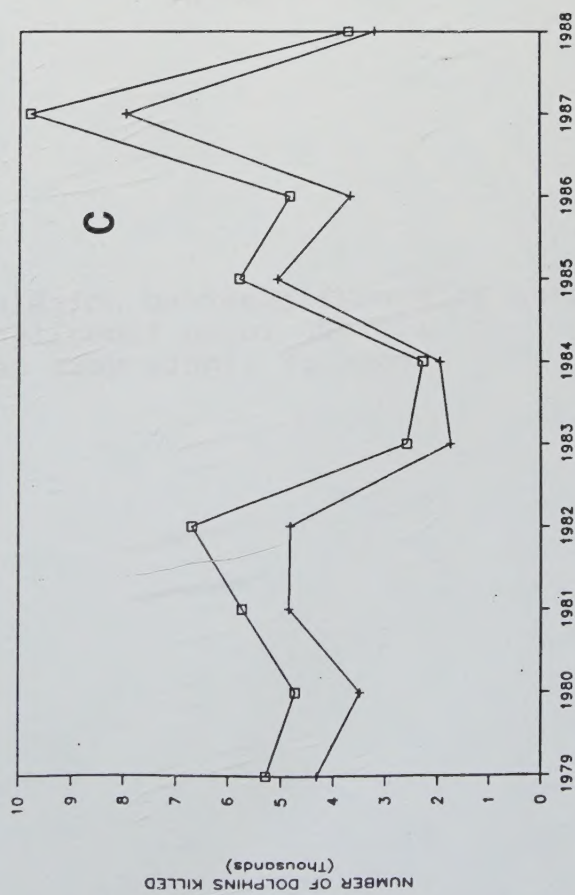


Figure 6. Annual percentages of observed dolphin sets with zero animals killed (A), 1-5 animals killed (B), 6-10 animals killed (C), 11-15 animals killed (D), and greater than 15 animals killed (E).



NUMBER OF DOLPHIN KILLED IN DAY SETS



NUMBER OF DOLPHIN KILLED IN NIGHT SETS

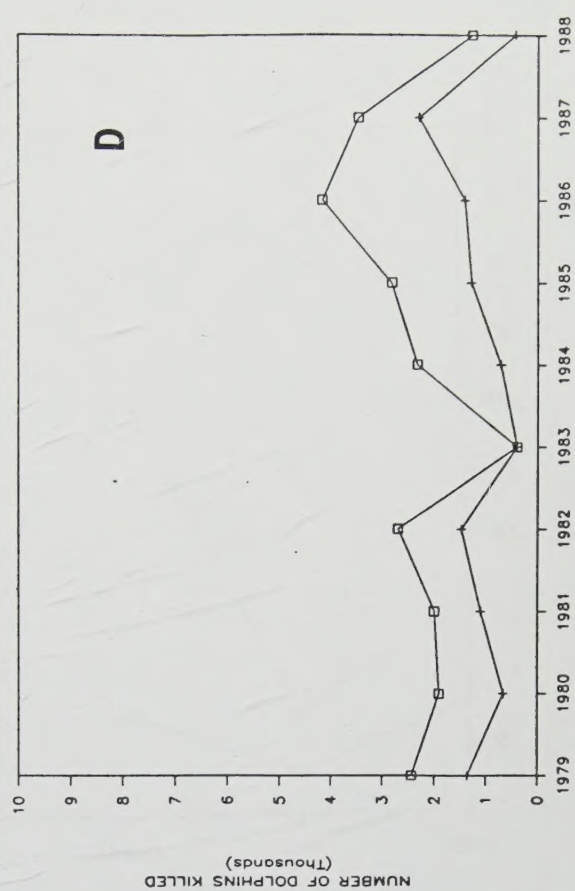


Figure 7: Annual observed dolphin kill/set in day sets (A) and night sets (B) and annual mortalities in day sets (C) and night sets (D) before and after sets with greater than 100 animals were eliminated.

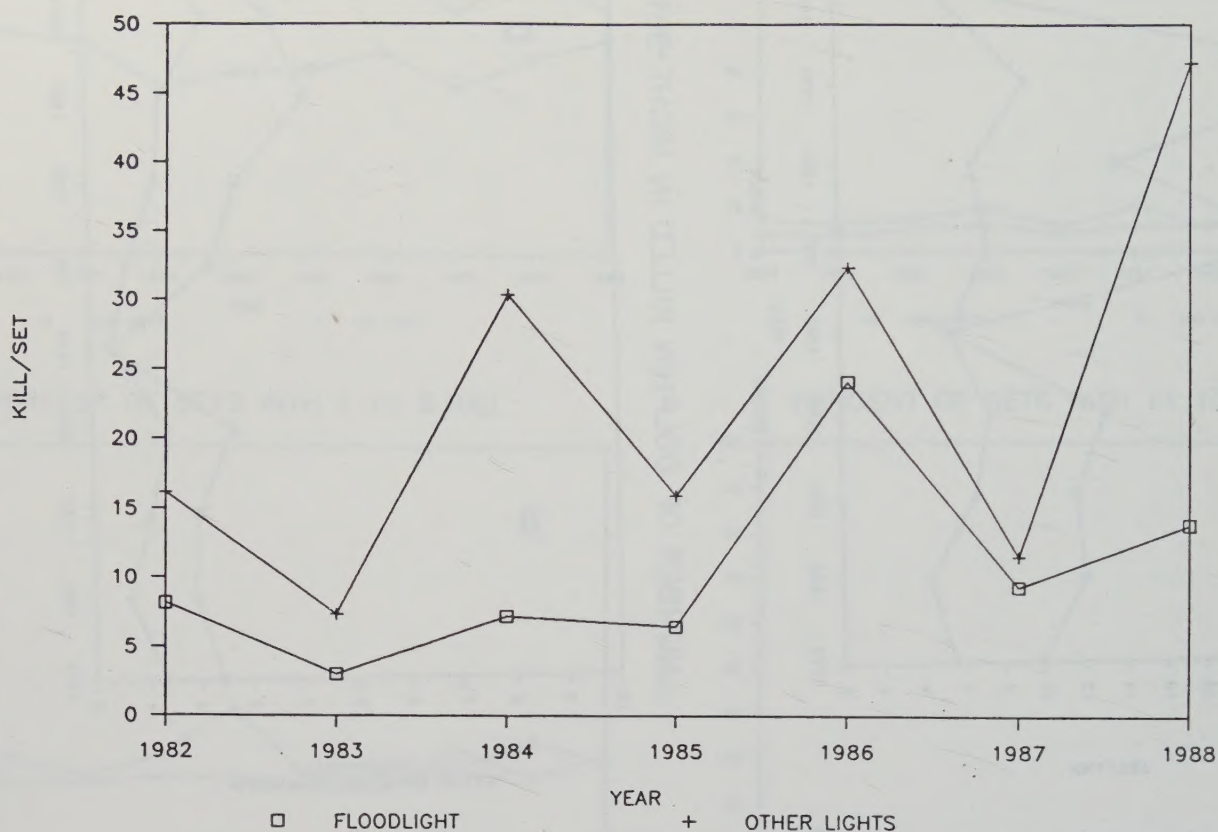


Figure 8: Annual observed dolphin kill/set in night sets where 140,000 lumen floodlights were used and where other types of lights were used.

